AMENDMENTS TO THE SPECIFICATION

Kindly add the following new paragraphs immediately before the Detailed Description of Preferred Embodiments on p. 15:

Fig. 2 illustrates the construction and mode of operation of a tripolar electrode device particularly useful in the present invention;

Fig. 3 diagrammatically illustrates an array of tripolar electrode devices constructed in accordance with the present invention for selectively blocking the propagation through certain nerve-fibers of body-generated action potentials;

Fig. 4 is a block diagram illustrating the stimulator in the apparatus of Fig. 3;

Fig. 5 is a block diagram illustrating the operation of the apparatus of Figs. 3 and 4 for suppressing pain sensations;

Figs. 6A and 6B are block diagrams illustrating how the apparatus of Figs. 3 and 4 may also be used for suppressing selected muscular or glandular activities controlled by the motor nerves;

Figs. 7A and 7B are block diagrams illustrating how the apparatus of Figs. 3 and 4 may also be used for stimulating selected motor or glandular activities upon the failure of the body to generate the required action potentials; and

Figs. 8A and 8B are diagrams helpful in explaining the manner of calibrating the apparatus of Figs. 3 and 4.

Kindly add the following new paragraphs immediately before the paragraph on p. 21 beginning with "It is to be understood. . . .":

According to another aspect of the present invention, there is provided a method of selectively suppressing the propagation of body-generated action potentials propagated in a predetermined direction at a first velocity through a first group of nerve fibers in a nerve bundle without unduly suppressing the propagation of body-generated action potentials propagated in the predetermined direction at a different velocity through a second group of nerve fibers in the nerve bundle, comprising: applying a plurality of electrode devices to, and spaced along the length of, the nerve bundle, each electrode device being capable of outputting, when actuated, unidirectional electrode-generated action potentials producing collision blocks with respect to the body-generated action potentials propagated through the second type of nerve fibers; and sequentially actuating the electrode devices with delays timed to the first velocity to produce a "green wave" of anodal blocks minimizing undesired blocking of the body-generated action potentials propagated through the first group of nerve fibers while maximizing the generation rate of said unidirectional electrode-generated action potentials producing collision blocks with respect to the body-generated action potentials propagated through said second type of nerve fibers.

Such a method may be used for producing collision blocks in sensory nerve fibers in order to suppress pain, and also in motor nerve fibers to suppress selected muscular or

glandular activities.

According to a further aspect of the invention, there is provided a method of selectively controlling nerve fibers in a nerve bundle having fibers of different diameters propagating action potentials at velocities corresponding to their respective diameters, comprising: applying a plurality of electrode devices to, and spaced along the length of, the nerve bundle, each electrode device being capable of producing, when actuated, unidirectional electrode-generated action potentials; and sequentially actuating the electrode devices with delays timed to the velocity of propagation of action potentials through the fibers of one of the diameters.

In some described preferred embodiments, the electrode devices are sequentially actuated to generate unidirectional action potentials producing collision blocks of the body-generated action potentials propagated through the nerve fibers of another diameter. Such collision blocks may be used for suppressing pain sensations without unduly interfering with normal sensations, or for selectively suppressing certain motor controls without unduly interfering with others.

A basic element in the preferred embodiments of the method and apparatus described below is the tripolar electrode device. Its construction and operation are diagrammatically illustrated in FIG. 2.

As shown in FIG. 2, the tripolar electrode device, therein designated 10, includes three electrodes, namely, a central

cathode 11, a first anode 12 on one side of the cathode, and a second anode 13 on the opposite side of the cathode. The illustrated tripolar electrode device further includes a microcontroller 14 for controlling the three electrodes 11, 12 and 13, as will be described below.

Curve 15 shown in FIG. 2 illustrates the activation function performed by the tripolar electrode device 10 on the nerve bundle underlying it. As shown in FIG. 2, this activation function includes a sharp positive peak 15a underlying the cathode 11, a relatively deep negative dip 15b underlying the anode 12, and a shallower negative dip 15c underlying the anode 13.

When the tripolar electrode 10 is placed with its cathode 11 and anodes 12, 13 in contact with, or closely adjacent to, a nerve bundle, the energization of the cathode 11 generates, by cathodic stimulation, action potentials in the nerve bundle which are propagated in both directions; the energization of anode 12 produces a complete anodal block to the propagation of the so-generated action potentials in one direction; and the energization of anode 13 produces a selective anodal block to the propagation of the action potentials in the opposite direction.

According to another aspect of the present invention, a plurality of electrode devices, preferably of such tripolar electrodes, are used to generate a sequence of electrode-generated action potentials (EGAPs) for more effectively suppressing the propagation of body-generated action potentials (BGAPs) propagated through sensory nerves towards the central nervous system (CNS) for pain control, as well as for suppressing the propagation of body-

generated action potentials propagated through motor nerves from the central nervous system towards the peripheral nervous system (PNS) for muscular or glandular stimulation or suppression. As will be described more particularly below, the plurality of electrode devices are sequentially actuated with delays to produce a "green wave" of unidirectional EGAPs effective to reduce the interference with the BGAPs propagated unhindered, or to reinforce the stimulation of muscular or glandular activities desired to be effected.

FIGS. 3 and 4 are diagrams illustrating one form of apparatus constructed in accordance with the present invention utilizing a plurality of the tripolar electrode devices, therein designated 10a--10n, shown in FIG. 2. Such electrode devices are interconnected by a bus 16 to form an electrode array 17 to be applied, as by implantation, with the electrode devices spaced along the length of the nerve bundle, shown at 19, and to be selectively actuated, as will be described more particularly below, by a stimulator, generally designated 21. The construction of the stimulator 21 is more particularly illustrated in FIG. 4.

Each of the electrode devices 10a--10n is of the tripolar construction shown in FIG. 2, to include a central cathode 11 flanked on its opposite sides by two anodes 12, 13. Each such electrode device further includes a microcontroller, shown at 14 in FIG. 2, and more particularly described below with respect to FIG. 8, for sequentially controlling the actuation of the electrodes 11-13 of each electrode device in order to produce the "green wave" briefly described above, and to be more particularly described below.

The assembly of electrode devices 10a--10n, and the stimulator 21 for sequentially actuating them, are preferably both implantable in the body of the subject with the electrodes in contact with, or closely adjacent to, the nerve bundle 15. Accordingly, the simulator 21 includes its own power supply, shown at 22 in FIG. 4. The stimulator 21 further includes a microcontroller 23 having output stage 24 connected, via connector block 25, to the plurality of electrode devices 10a--10n for sequentially actuating them, as will be described below.

Stimulator 21 further includes an input circuit for inputting various sensor signals for purposes of calibration and/or control. As shown in FIG. 4, such inputs may be from an EMG (electromyogram) signal sensor 26a and from an accelerator sensor 26b. The EMG sensor 26a may be used for calibration purposes, e.g., to calibrate the apparatus according to EMG signals generated by a subject's muscle during the calibration of the apparatus (described below), or for control purposes, e.g., for automatically actuating the device upon the occurrence of a particular EMG signal. The accelerator sensor 26b may be used for control purposes, e.g., to automatically actuate the device upon the occurrence of tremors or spasms in order to suppress in the tremors by blocking certain motor nerves.

Stimulator 21 may also have an input from a perspiration sensor 26c for automatic control of sweat glands. It may also have an input from one of the electrodes serving as a reference electrode for calibration purposes, as will also be described more particularly below.

The inputs into the stimulator 21 may be by wire or bus, as shown at 27 in FIG. 4. Such inputs are amplified in amplifier 28, and digitized in a digitizer 29, before being inputted into the microcontroller 23.

The inputs to the stimulator 21 may also be by wireless communication, as schematically shown at 32 in FIG. 4, particularly where the device is implanted. For this purpose, stimulator 21 includes a receiver 31 for receiving such inputs. Such inputs are also amplified in amplifier 28 and digitized in digitizer 29 before being inputted into the microcontroller 23.

Operation of the Illustrated Apparatus

The apparatus illustrated in FIGS. 3 and 4, when applied along the length of the nerve bundle 15 as shown in FIG. 3, is capable of suppressing the propagation of body-generated action potentials (BGAPs) propagated through the small-diameter nerve fibers in a nerve bundle without unduly suppressing the propagation of BGAPs propagated through the large-diameter nerve fibers in the nerve bundle. One application of such a device is to reduce pain sensations; and another application of the device is to suppress muscular or glandular activities. The apparatus illustrated in FIGS. 3 and 4 may also be used for generating, by the electrode devices, action potentials (hereinafter frequently referred to as electrode-generated action potentials, or EGAPS) where the body fails to produce the necessary BGAPs to produce a particular muscular or glandular activity. A further application of the apparatus, therefore, is to stimulate a muscular or glandular

activity.

As described above, when the cathode 11 of each tripolar electrode device 10 is actuated, it generates an action potential by cathodic stimulation propagated in both directions; whereas when anode 12 of the respective tripolar electrode 10 is energized, it produces a complete anodal block on one side of the cathode, to thereby make the electrode-generated action potential unidirectional and propagated away from the central nervous system. On the other hand, when anode 13 is energized, it produces an anodal block only with respect to the BGAPs propagated through the large-diameter sensory nerves, since they are more sensitive to the anodal current. Accordingly, the EGAPs from the small-diameter sensory nerves are permitted, to a larger extent, to propagate through the anodal block.

The EGAPs outputted by the anodal block may be used as collision blocks with respect to sensory BGAPs to suppress pain, or with respect to motor BGAPs to suppress undesired muscular activity (e.g., tremors, spasms), or glandular activity (e.g., excessive perspiration).

An undesired side effect of this activation scheme, is that at the time when anode 12 of device 10 is actuated to generate an anodal block as described above, all BGAPs in both small and large fibers are blocked and cannot pass the device. Thus every production of an EGAP is accompanied by a brief period in which all BGAPs cannot pass the site of the device 10. In order to minimize the blocking of BGAPs while maximizing the amount of EGAPs produced, the tripolar electrode devices 10a--10n are sequentially actuated, under the control of the stimulator 21. This sequential actuation

is timed with the propagation velocity of the action potentials through the nerve fiber not to be blocked. Thus, as well known for controlling vehicular traffic, when stop lights spaced along a thoroughfare are controlled to define a "green wave" travelling at a predetermined velocity, the vehicles travelling at the "green wave" velocity will be less hindered than if the stop lights were not synchronized with their velocity.

The anodal blocks produced by the sequential actuation of the tripolar electrodes are comparable to the stop lights in a thoroughfare, and therefore the action potentials travelling at the velocity of the green wave will be less hindered by such stop lights or anodal blocks.

Thus, where the invention is used for pain control by suppressing the BGAPs in the small-diameter sensory nerves, producing a "green wave" of anodal blocks timed with the conduction velocity through the large-diameter sensory nerves, there will be less interference with the BGAPs representing normal sensations, travelling through the large-diameter sensory nerve fibers, as compared to the BGAPs representing pain sensations travelling through the small-diameter sensory nerve fibers which will be collision blocked by the EGAPs.

The same "green wave" effect can be provided in order to suppress BGAPs propagating through motor nerve fibers in order to block motor controls of selected muscles or glands.

Examples of Use of the Apparatus

FIG. 5 illustrates an example of use of the described apparatus for reducing pain sensations by suppressing the BGAPs transmitted through the small-diameter sensory fibers without unduly hindering the transmission of the BGAPs through the large-diameter sensory fibers.

Thus, as shown in FIG. 5, the BGAPs in the peripheral nervous system PNS (block 39) generate normal sensations in the large sensory fibers 41 and pain sensations in the small sensory fibers 42. Normally, both types of sensations are propagated through their respective fibers to the central nervous system (CNS, block 43).

However, as shown in FIG. 5, the assembly of electrodes 10a--10n, when sequentially actuated with delays timed to the conduction velocity of the large-diameter fibers 41, generates unidirectional EGAPs (block 44) which are outputted with delays timed to correspond to the velocity of the large sensory fibers (as shown at 45) to produce a collision block (46) with respect to the BGAPs propagated through the small sensory fibers (42) without unduly hindering the BGAPs propagated through the large sensory fibers 41 to the central nervous system 43. Accordingly, the pain sensations normally propagated through the small sensory fibers 42 to the central nervous system 43 will be suppressed, while the normal sensations propagated through the large sensory fibers 41 will continue substantially unhindered to the central nervous system.

In addition, as shown by line 47 in FIG. 5, the motor action potentials from the CNS to the PNS are also

substantially unhindered.

FIGS. 6A and 6B illustrate the application of the apparatus for suppressing certain muscular or glandular activities normally controlled by the BGAPs transmitted through the motor nerve fibers. In this case, as shown in FIG. 6A, the BGAPs are generated in the central nervous system (block 49) and are normally transmitted via large motor fibers 51 and small motor fibers 52 to the peripheral nervous system 53. FIG. 6B illustrates the arrangement wherein the EGAPs are generated at a rate corresponding to the velocity of the large motor fibers, as shown by blocks 54 and 55, so that they produce collision blocks with respect to the small motor fibers 52, and permit the BGAPs to be transmitted through the large motor fibers 51 to the peripheral nervous system 53.

FIG. 6B illustrates the variation wherein the apparatus generates EGAPs at a rate corresponding to the velocity of the small motor fibers (blocks 54, 55), such that the collision blocks (56) block the large motor fibers 51, and permit the BGAPs to be transmitted to the peripheral nervous system 53.

FIGS. 7A and 7B illustrate the applications of the apparatus for stimulating a particular muscle or gland where the body fails to develop adequate BGAPs in the respective motor nerve fiber for the respective muscular or glandular control. In this case, the apparatus generates unidirectional EGAPs selectively for the respective muscle or gland.

FIG. 7A illustrates the application of the invention wherein the body fails to generate in the central nervous system 61 adequate BGAPs for transmission by the large motor fibers to the peripheral nervous system 63, in which case the electrode devices 10a--10n in the electrode assembly would be sequentially energized by the stimulator 64 with delays timed to the velocity of propagation of action potentials through the large motor fibers. The unidirectional EGAPs are thus produced with delays timed to the conductive velocity of the large motor fibers, thereby permitting them to be transmitted via the large motor fibers to the peripheral nervous system.

FIG. 7B, on the other hand, illustrates the case where the electrodes 10a--10n are sequentially energized with delays timed to the velocity of the small motor fibers, thereby permitting the unidirectional EGAPs to be outputted via the small-diameter fibers to the peripheral nervous system 63.

Calibration

For best results, each electrode assembly should be calibrated for each patient and at frequent intervals. Each calibration requires adjustment of the cathodic and anodic currents in each tripolar electrode, and also adjustment of the timing of the sequential actuation of the tripolar electrodes.

To calibrate the cathodic and anodic currents for each electrode, the proximal electrode (10a, FIG. 3) is actuated to produce a unidirectional action potential propagated towards the distal electrode (10n) at the opposite end of the array. The so-produced action potential, after having

traversed all the electrodes between electrodes 10a, and 10n, is detected and recorded by the distal electrode 10n. The currents in the electrodes are iteratively adjusted to produce maximum blocking.

FIG. 8A illustrates, at "a", the signal detected by the distal electrode when the blocking is minimum, and at "b" when the signal detected by the distal electrode when the blocking is maximum.

FIG. 8B illustrates the manner of calibrating the electrode array to produce the proper timing in the sequential actuation of the electrodes for calibrating the sequential timing, the proximate electrode (10a) is again actuated to produce a unidirectional action potential propagated toward the distal electrode (10n). As the so-produced action potential traverses all the electrodes inbetween, each such inbetween electrode detects and records the action. This technique thus enables calibrating the electrode array to produce the exact delay between the actuations of adjacent electrodes to time the sequential actuations with the conduction velocity of the respective nerve fiber.

For example, where the sequential actuation is to produce a "green wave" having a velocity corresponding to the conduction velocity of the large sensory nerve fibers for reducing pain sensations, the timing would be adjusted so as to produce the sequential delay shown in FIG. 8B to thereby time the sequential actuations of the electrodes to the conductive velocity in the large sensory fibers.

The EMG sensor 26a shown in FIG. 4 may also be used for

calibrating the electrode currents and sequential timing when the apparatus is to be used for providing a stimulation of a muscular or glandular activity where the body fails to provide the necessary BGAPs for this purpose. In this case, the currents and timing would be adjusted to produce a maximum output signal from the EMG sensor 26a for the respective muscle.

The EMG sensor 26a could also be used to automatically actuate the apparatus upon the detection of an undesired EMG signal, e.g., as a result of a tremor or spasm to be suppressed. For example, the accelerator sensor 26b could be attached to a limb of the subject so as to automatically actuate the apparatus in order to suppress tremors in the limb upon detection by the accelerator.

Other sensors could be included, such as an excessive perspiration sensor 26c, FIG. 4. This would also automatically actuate the apparatus to suppress the activity of the sweat glands upon the detection of excessive perspiration.

A method is provided of reducing pain sensations resulting from the propagation of body-generated action potentials towards the central nervous system through small-diameter sensory fibers in a nerve bundle, without unduly reducing other sensations resulting from the propagation of body-generated action potentials towards the central nervous system through large-diameter sensory fibers in the nerve bundle, comprising:
applying to the nerve bundle at least one electrode device capable, upon actuation, of generating unidirectional action potentials to be propagated through both the small-

diameter and large-diameter sensory fibers in the nerve bundle away from the central nervous system; and

actuating the electrode device to generate the unidirectional action potentials to produce collision blocks with respect to the body-generated action potentials propagated through the small-diameter fibers.

The electrode device may include electrodes which:

(i) generate the electrode-generated action potentials by cathodic stimulation;

(ii) produce a complete anodal block on one side of the cathode to make the electrode-generated action potentials unidirectional; and

(iii) produce a selective anodal block on the opposite side of the cathode to cause the electrode-generated action potentials to produce collision blocks with respect to the body-generated action potentials propagated through the small-diameter sensory fibers.

The electrode device may be a tripolar electrode device which includes a central cathode for producing the cathodic stimulation, a first anode on one side of the cathode for producing the complete anodal block, and a second anode on the opposite side of the cathode for producing the selective anodal block. There may be a plurality of the electrode devices spaced along the length of the nerve bundle; and wherein the electrode devices are sequentially actuated with delays timed to the velocity of propagation of the body-generated action potentials through the large-diameter fibers to produce a "green wave" of electrode-generated anodal blocks, thereby increasing the number of EGAPs in the small diameter fibers producing collision

blocks while minimizing anodal blocking of the BGAPs propagated through the large-diameter sensory fibers.

A method is provided of selectively suppressing the propagation of body-generated action potentials propagated in a predetermined direction at a first velocity through a first group of nerve fibers in a nerve bundle without unduly suppressing the propagation of body-generated action potentials propagated in the predetermined direction at a different velocity through a second group of nerve fibers in the nerve bundle, comprising:
applying a plurality of electrode devices to, and spaced along the length of, the nerve bundle, each electrode device being capable of outputting, when actuated, unidirectional electrode-generated action potentials producing collision blocks with respect to the body-generated action potentials propagated through the second type of nerve fibers;
and sequentially actuating the electrode devices with delays timed to the first velocity to produce a "green wave" of anodal blocks minimizing undesired blocking of the body-generated action potentials propagated through the first group of nerve fibers, while maximizing the generation rate of the unidirectional electrode-generated action potentials producing collision blocks with respect to the body-generated action potentials propagated through the second type of nerve fibers.

The first group of nerve fibers may be large-diameter nerve fibers; and the second group of nerve fibers are small-diameter nerve fibers. The nerve fibers may be sensory nerve fibers, in which the predetermined direction of propagation of the body-generated action potentials to be

collision blocked is towards the central nervous system, the method being effective for suppressing pain sensations propagated through the small-diameter sensory fibers without unduly suppressing other sensations propagated through the large-diameter sensory fibers.

The nerve fibers may be motor nerve fibers in which the predetermined direction of propagation of the body-generated action potentials to be collision blocked is away from the central nervous system towards a muscle or gland, the method being effective for suppressing motor impulses propagated through the small-diameter motor nerve fibers without unduly suppressing the propagation of the motor impulses through the large-diameter motor nerve fibers.

Each of the electrode devices may be a tripolar electrode which includes a central cathode for producing the electrode-generated action potentials by cathodic stimulation, a first anode on one side of the cathode for making the electrode-generated action potentials unidirectional, and a second anode on the opposite side of the cathode for producing the selective anodal blocking of the electrode-generated action potentials.

A method is provided of selectively controlling nerve fibers in a nerve bundle having fibers of different diameters propagating action potentials at velocities corresponding to their respective diameters, comprising:
applying a plurality of electrode devices to, and spaced along the length of, the nerve bundle, each electrode device being capable of producing, when actuated, unidirectional electrode-generated action potentials;
and sequentially actuating the electrode devices with

delays timed to the velocity of propagation of action potentials through the fibers of one of the diameters.

The electrode devices may be sequentially actuated to generate unidirectional action potentials producing collision blocks of the body-generated action potentials propagated through the nerve fibers of a another diameter. The electrode devices may be sequentially actuated with delays timed to the velocity of the larger-diameter nerve fibers to produce a "green-wave" of anodal blocks in order to minimize blocking the body-generated action potentials propagated through the larger-diameter fibers while maximizing the number of EGAPs collision blocking the body-generated action potentials propagated through the small diameter fibers. The fibers may include large-diameter sensory fibers propagating body-generated action potentials representing normal sensations from the peripheral nervous system to the sensor nervous system, and small-diameter sensory fibers propagating body-generated action potentials representing pain sensations from the peripheral nervous system to the central nervous system, which pain sensations in the small-diameter sensory fibers are suppressed by collision block and the "green-wave" of anodal blocks minimizes blocking of the normal sensations in the large-diameter sensory nerves. The nerve fibers may include large-diameter motor fibers propagating body-generated action potentials representing certain motor controls from the central nervous system to the peripheral nervous system, and small-diameter motor nerve fibers representing other motor controls from the central nervous system to the peripheral nervous system, the motor controls in the small-diameter motor fibers being suppressed by collision blocks and the green-wave of anodal blocks minimizes blocking of the motor controls in the large-diameter motor fibers.

The nerve fibers may be motor fibers of different diameters for propagating body-generated action potentials from the central nervous system to the peripheral nervous system, the electrode devices being sequentially actuated to generate unidirectional action potentials to serve as motor action potentials to be propagated from the central nervous system to the peripheral nervous system to replace motor action potentials failed to be generated by the body.

Each of the electrode devices may be a tripolar electrode which includes a central cathode for producing the electrode-generated action potentials by cathodic stimulation, a first anode on one side of the cathode for making the electrode-generated action potentials unidirectional, and a second anode on the opposite side of the cathode for producing the selective anodal blocking of the electrode-generated action potentials.

Apparatus is provided for selectively blocking pain sensations resulting from the propagation of body-generated action potentials towards the central nervous system through small-diameter sensory fibers in a nerve bundle, without unduly reducing other sensations resulting from the propagation of body-generated action potentials towards the central nervous system through large-diameter sensory fibers in the nerve bundle, comprising:
an electrical device to be applied to the nerve bundle and having at least one electrode device capable, upon actuation, of generating unidirectional action potentials to be propagated through both the small-diameter and large-diameter sensory fibers in the nerve bundle away from the central nervous system;

and a stimulator for actuating the electrode device to generate the unidirectional action potentials to produce collision blocks of the body-generated action potentials in the small-diameter sensory fibers.

The electrode device may include electrodes which:

(a) generate the electrode-generated action potentials by cathodic stimulation;

(b) produce a complete anodal block on one side of the cathode to make the electrode-generated action potentials unidirectional; and

(c) produce a selective anodal block on the opposite side of the cathode to block the electrode-generated action potentials propagated through the large-diameter sensory fibers to a greater extent than those propagated through the small-diameter sensory fibers.

The electrode device may be a tripolar electrode which includes a central cathode for producing the cathodic stimulation, a first anode on one side of the cathode for producing the complete anodal block, and a second anode on the opposite side of the cathode for producing the selective anodal block. There may be a plurality of the electrode devices spaced along the length of the nerve bundle; and wherein the electrode devices are sequentially actuated with delays corresponding to the velocity of propagation of the body-generated action potentials through the large-diameter fibers to produce a "green wave" of electrode-generated action potentials collision blocking with the body-generated action potentials propagated through the small-diameter fibers while minimizing anodal blocking of action potentials propagating through the large-diameter fibers.

Apparatus is provided for selectively suppressing the propagation of body-generated action potentials propagated at a first velocity through a first type of nerve fibers in a nerve bundle without unduly suppressing the propagation of body-generated action potentials propagated at a different velocity through a second type of nerve fibers in the nerve bundle, comprising:

spacing a plurality of electrodes to be spaced along the length of the nerve bundle, each capable of producing, when actuated, unidirectional electrode-generated action potentials and a selective anodal block of the latter action potentials propagated through the first type of nerve fibers to a greater extent than those propagated through the second type of nerve fibers;

and a stimulator for sequentially actuating the electrode devices with delays timed to the first velocity to produce a "green wave" of anodal blocks minimizing undesired blocking of the body-generated action potentials propagated through the first group of nerve fibers, while maximizing the generation rate of the unidirectional electrode-generated action potentials producing collision blocks with respect to the body-generated action potentials propagated through the second type of nerve fibers.

Each of the electrode devices may be a tripolar electrode which includes a central cathode for producing the electrode-generated action potentials by cathodic stimulation, a first anode on one side of the cathode for making the electrode-generated action potentials unidirectional, and a second anode on the opposite side of the cathode for producing the selective anodal blocking of the electrode-generated action potentials. The plurality

of electrode devices and the stimulator may be constructed to be implanted into the subject's body with the electrodes in contact with or closely adjacent to the nerve bundle.

The stimulator may be connected to the plurality of electrode devices by an asynchronous, serial four-wire bus. The stimulator may communicate with the plurality of electrode devices via a wireless communication link. Each of the tripolar electrode devices may include an insulating base carrying the cathode and two anodes on one face thereof, and control circuitry on the opposite face. The control circuitry may include a microprocessor communicating with the stimulator, and an L-C pulsing network controlled by the microprocessor.

Apparatus is provided for selectively controlling nerve fibers in a nerve bundle having fibers of different diameters propagating action potentials at velocities corresponding to their respective diameters, comprising:
a plurality of electrode devices to be applied to, and spaced along the length of, the nerve bundle, each electrode device being capable of producing, when actuated, unidirectional electrode-generated action potentials;
and a stimulator for sequentially actuating the electrode devices with delays timed to the velocity of propagation of action potentials through the fibers of one of the diameters.

The stimulator may sequentially actuate the electrode devices to generate unidirectional action potentials producing collision blocks of the body-generated action potentials propagated through the nerve fibers of a another diameter. The stimulator may sequentially actuate the

electrode devices with delays corresponding to the velocity of larger-diameter nerve fibers to produce a "green-wave" of anodal blocks minimizing undesired blocking of the body-generated action potentials propagated through the large-diameter nerve fibers, while maximizing the generation rate of the unidirectional electrode-generated action potentials producing collision blocks with respect to the body-generated action potentials propagated through the small diameter nerve fibers.

The nerve fibers may be motor fibers of different diameters for propagating body-generated action potentials from the central nervous system to the peripheral nervous system, and the stimulator may sequentially actuate the electrode devices to generate unidirectional action potentials to serve as motor action potentials to be propagated from the central nervous system to the peripheral nervous system to replace motor action potentials failed to be generated by the body.